Supercritical CO_2 Power Cycles Symposium

Static and Transient Characteristics of a Microchannel Two-phase Looped Thermosyphon Cooler for the sCO_2 Brayton Cycle

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Introduction

Background:

The cooling process in the supercritical CO_2 Brayton cycle is conventionally realized by forced convection of single-phase water. Due to the limited capability of sensible heat transfer, the requirement for mass flow rate of cooling water is large, and considerable pump power is consumed accordingly. Additionally, owing to the large thermal inertia of liquid water, the temperature response is slow during load variation.

Objective:

In this work, the forced convection liquid water cooler is replaced by a two-phase microchannel looped thermosyphon to significantly enhance the cooling process to precisely and rapidly regulate the CO_2 temperature at the compressor, thereby improving the cycle efficiency and system compactness.

System introduction

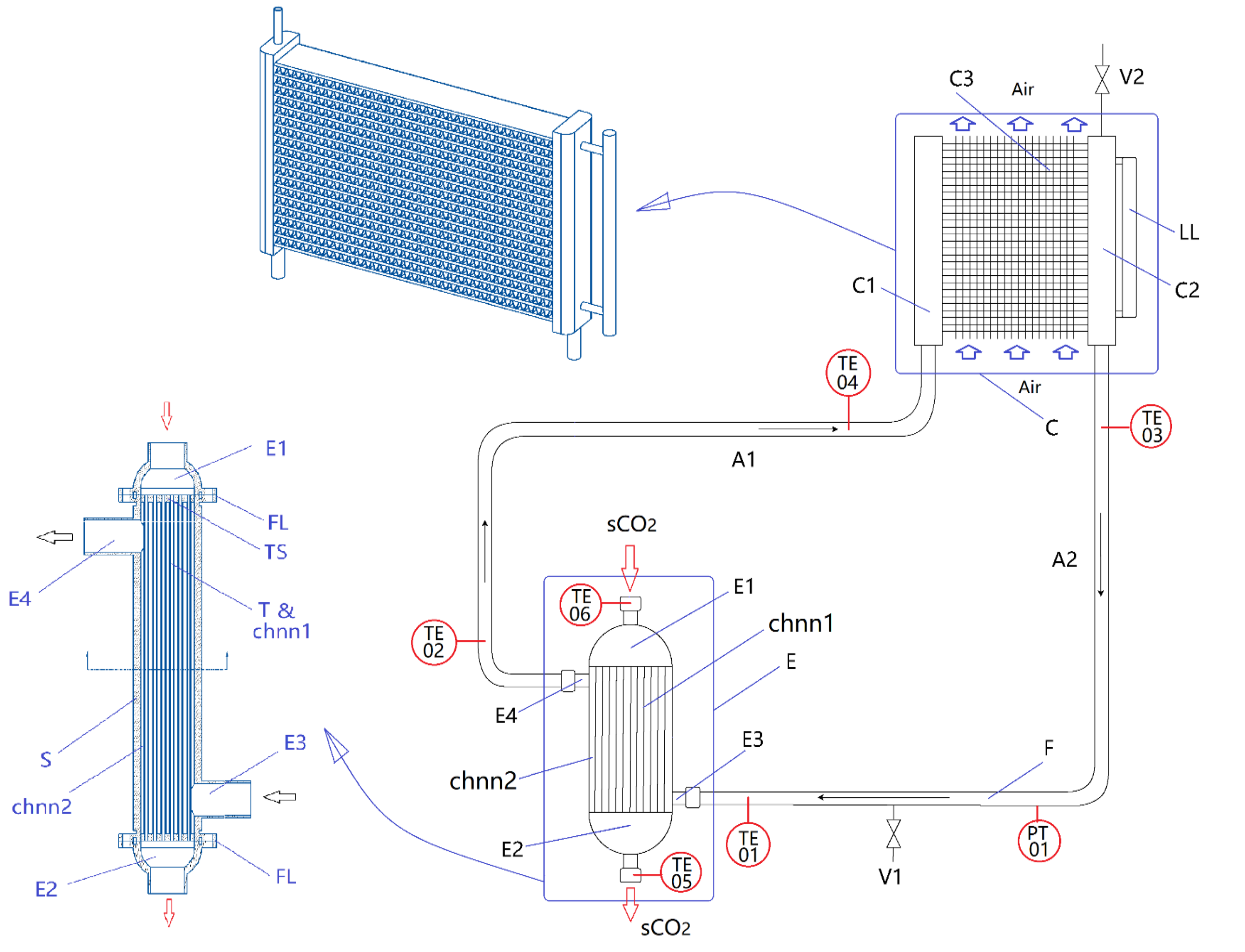
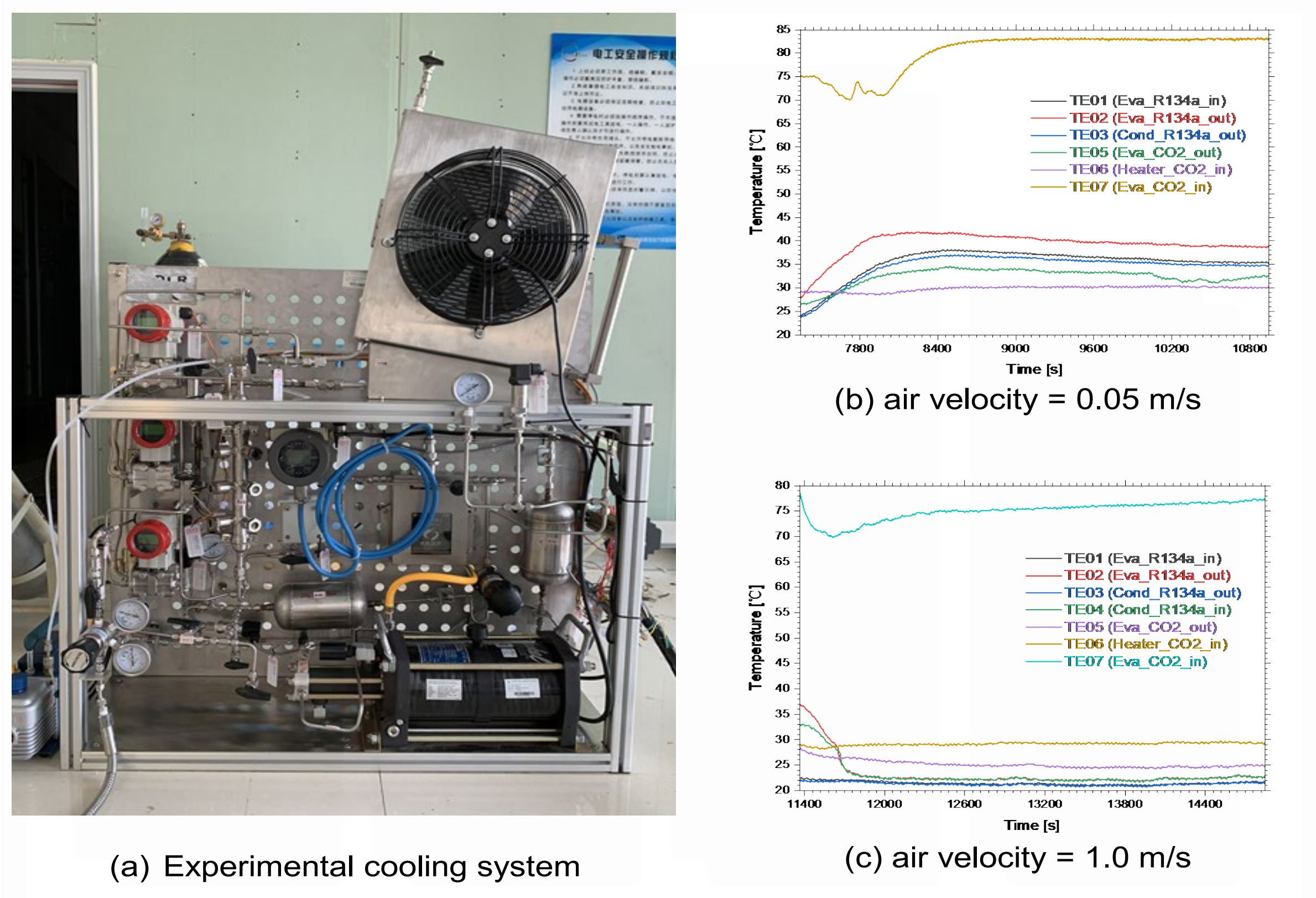


Fig. 1 Schematic diagram of supercritical CO_2/R134a microchannel heat pipe cooler

E - Evaporator; C - Condenser; A1 - R134a vapor line; A2 - R134a condensate return line; TE - Temperature elements; PT - Pressure transducer

Results & Discussion



(a) Experimental cooling system

(b) air velocity = 0.05 m/s

(c) air velocity = 1.0 m/s

Fig. 2 Experimental validation of the simulation model

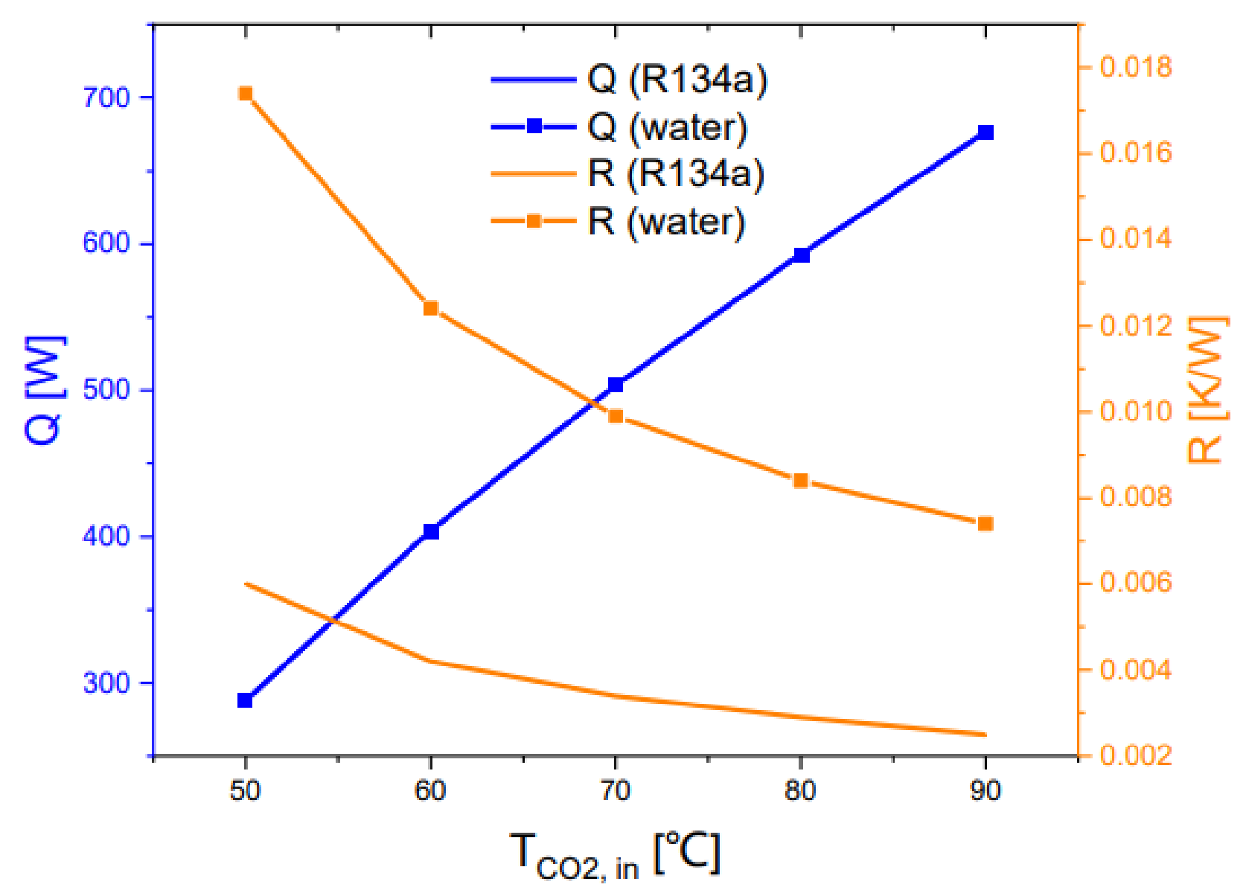


Fig.3 Effect of CO_2 inlet temperature on the loop thermal resistance

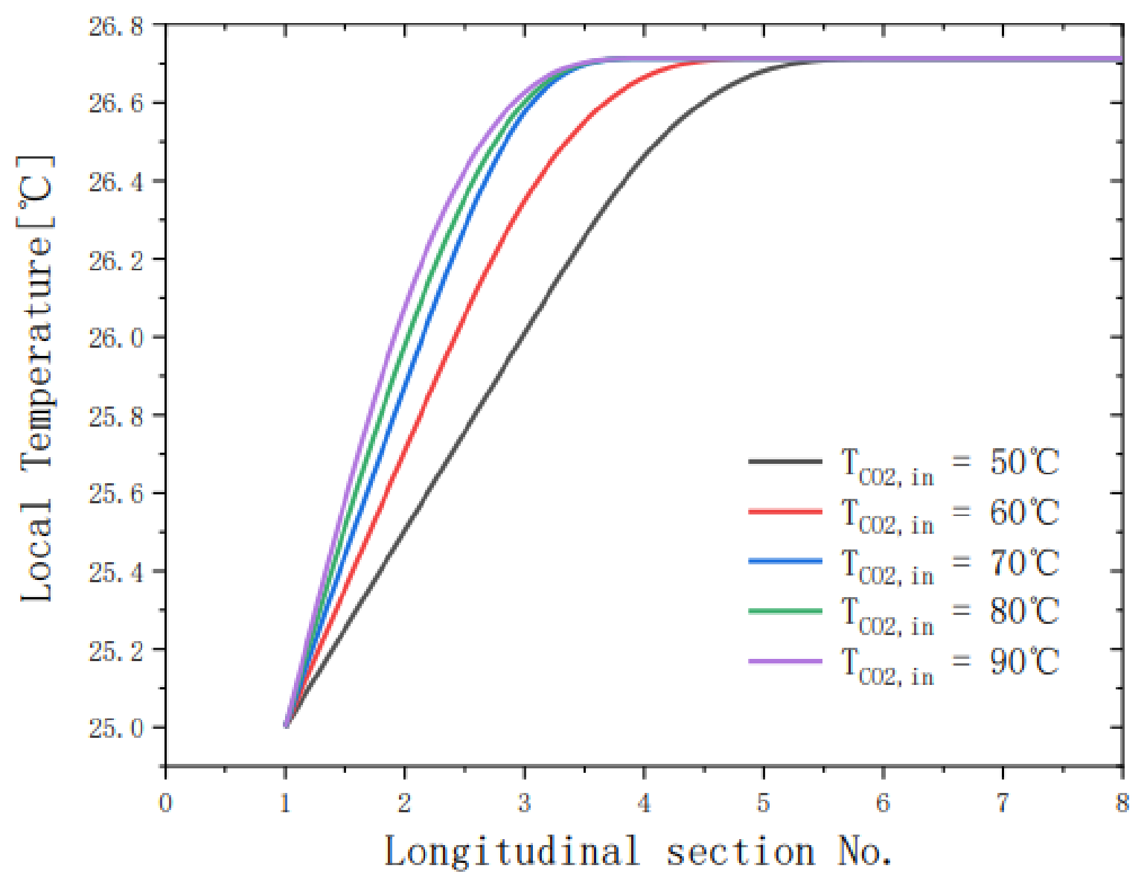


Fig.4 Effect of CO_2 inlet temperature on the R134a temperature distribution in the evaporator

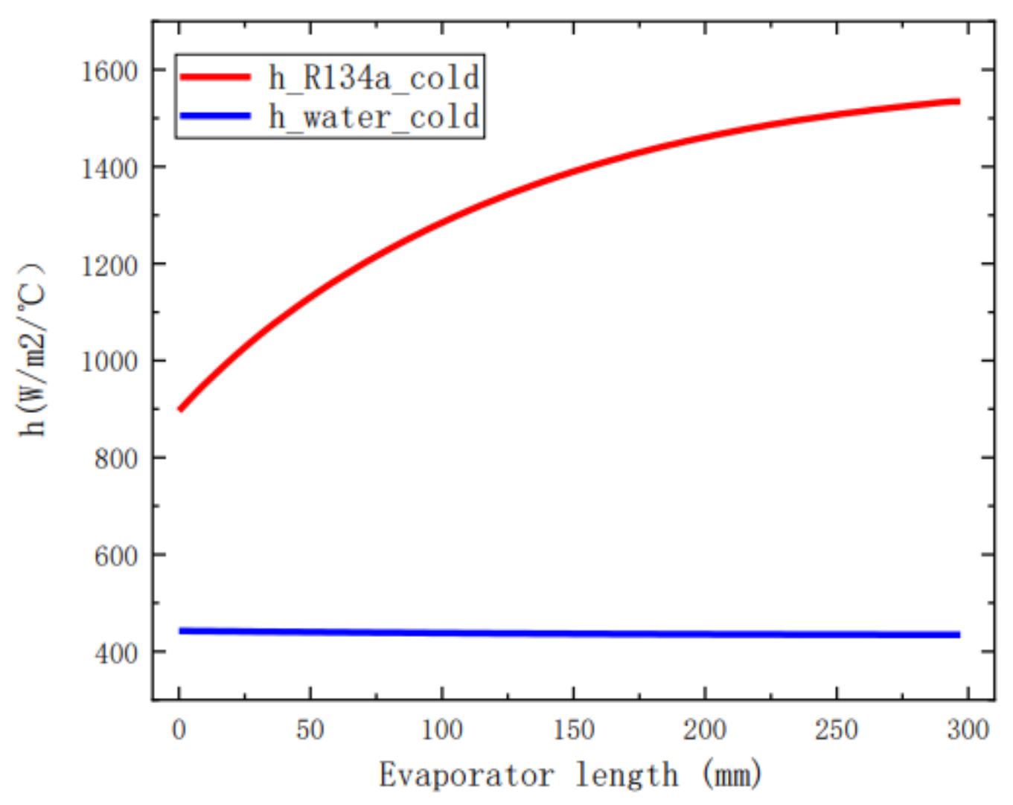


Fig.5 The longitudinal distribution of the coolant heat transfer coefficient

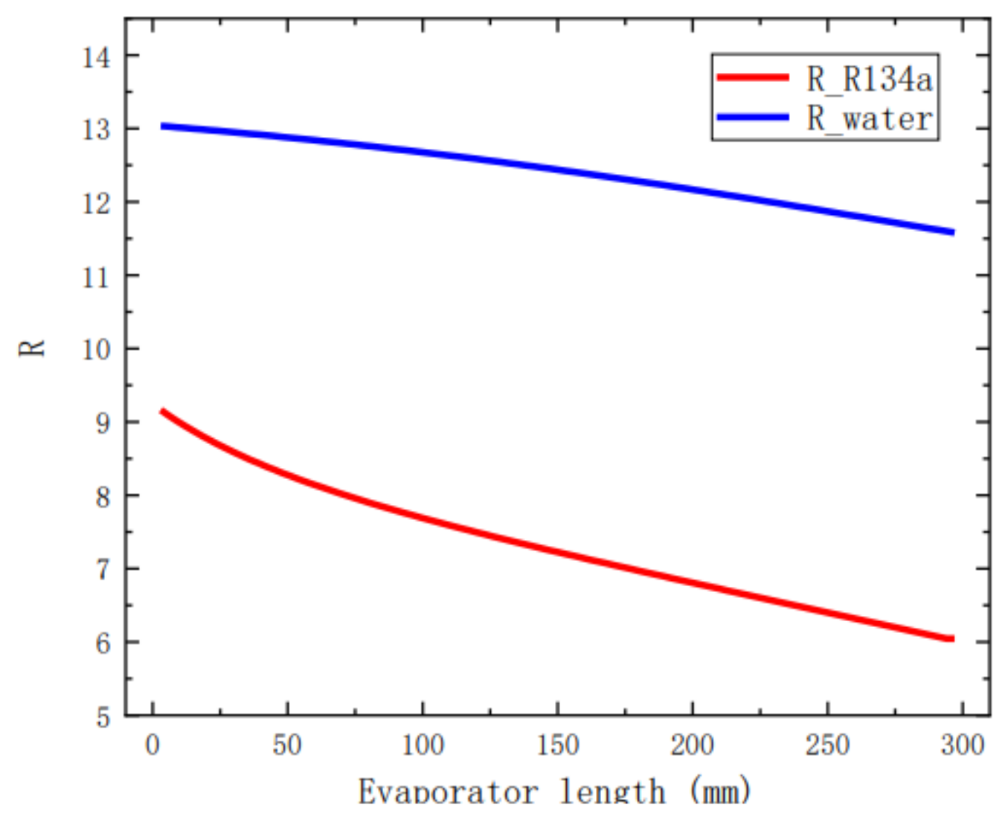


Fig.6 The longitudinal distribution of the evaporator local thermal resistance

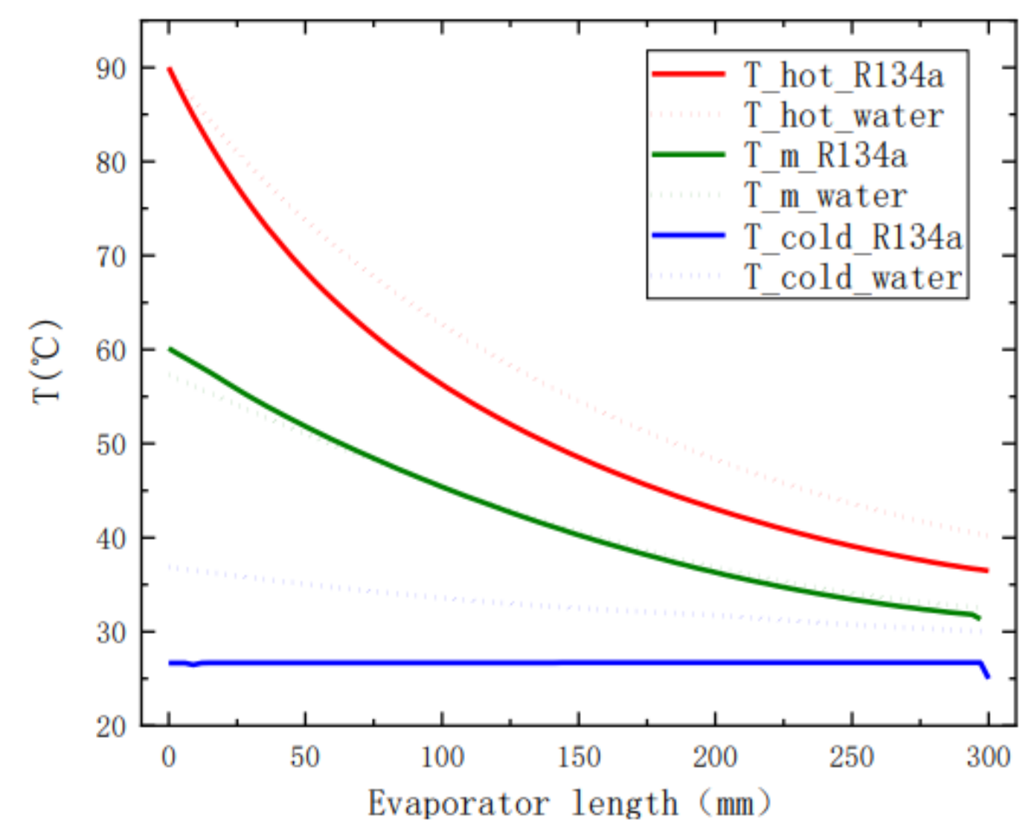


Fig.7 Temperature distribution along the evaporator

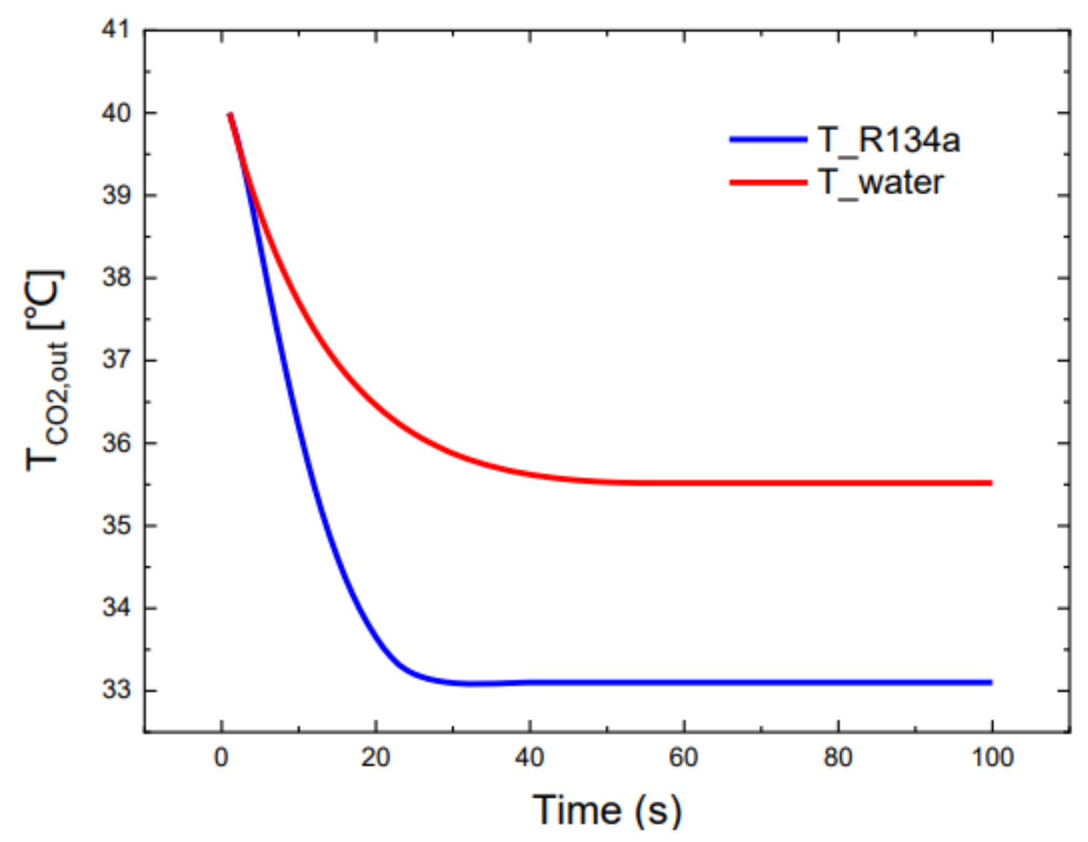


Fig.8 Transient variation of CO_2 outlet temperature with time

Main Conclusions

The steady-state simulation results show that, the heat transfer coefficient of the R134a two-phase looped thermosyphon is much higher than that of the forced convection of liquid water, leading to smaller thermal resistance, and thus could significantly reduce the average CO_2 temperature in the heat releasing process, which may contribute to promotion of thermal efficiency of the Brayton cycle. The dynamic simulation results show that, the CO_2 outlet temperature can be more quickly and accurately regulated due to the high phase-change heat transfer capability, smaller mass flow rate, and less thermal inertia.

Acknowledgements

The authors gratefully acknowledge the financial support from the National Natural Science Foundation of China (Grant No. 52076206), the CAS Project for Young Scientists in Basic Research (Grant No.YSBR-043), and the Major National Science and Technology Infrastructure (No. 2017-000052-73-01-001569).

8th International Supercritical CO_2 Power Cycles • February 27 – 29, 2024 • San Antonio, TX, USA